Power Plant Operations, Maintenance, and Reporting, South Pole Station

OP-S-321

Revision 3

Approved by [redacted]

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Active Divisions/Departments:
South Pole Area Directorate

FEMC

Raytheon Polar Services Company
South Pole Area Directorate
Contract No. OPP 0000373

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Table of Contents

Purpose

To define operations, maintenance, and reporting procedures for the South Pole Power Plant.

Scope/Applicability

This procedure applies to all personnel working in/operating the South Pole Power Plant.

Terms and Definitions

AN8
Fuel used in power plant and aircraft

BOD
Basis of Design document

CO2
Carbon Dioxide

COMMS
South Pole Communications Center

DDC
Direct Digital Control

EH&S
Environmental, Health, and Safety

F
Degrees Fahrenheit

FEMC
Facilities, Engineering, Maintenance, and Construction

GCM
Generator Control Module

GPM
Gallons Per Minute

KW
Kilowatt

MAPCON
Software used for documenting equipment inventory and maintenance

rpm
Revolutions per minute

SITREP
Weekly station situation report

SPSE/SM
South Pole Safety and Environmental/Station Modernization project: new station facilities

Station Manager
South Pole Area Director or his/her designee, responsible for all on-site station operations

Responsibilities

The Facility Engineer is responsible for oversight and coordination of all maintenance in the power plant. It is the responsibility of each work center requiring access to the power plant to coordinate work with the Facility Engineer. All work center managers are required to ensure personnel working in the power plant are familiar with applicable procedures prior to doing work, and that all personnel are familiar with safety requirements applicable to the facility.

All personnel entering the facility are responsible for making sure proper safety equipment is used, and all sign-in and sign-out procedures are followed. All work will be logged and documented correctly using the MAPCON work order system.

The Power Plant Operator and Power Plant Mechanic are responsible for taking regularly scheduled readings and monitoring the equipment. Tracking reports as well as general cleaning duties are assigned by the Facility Engineer.

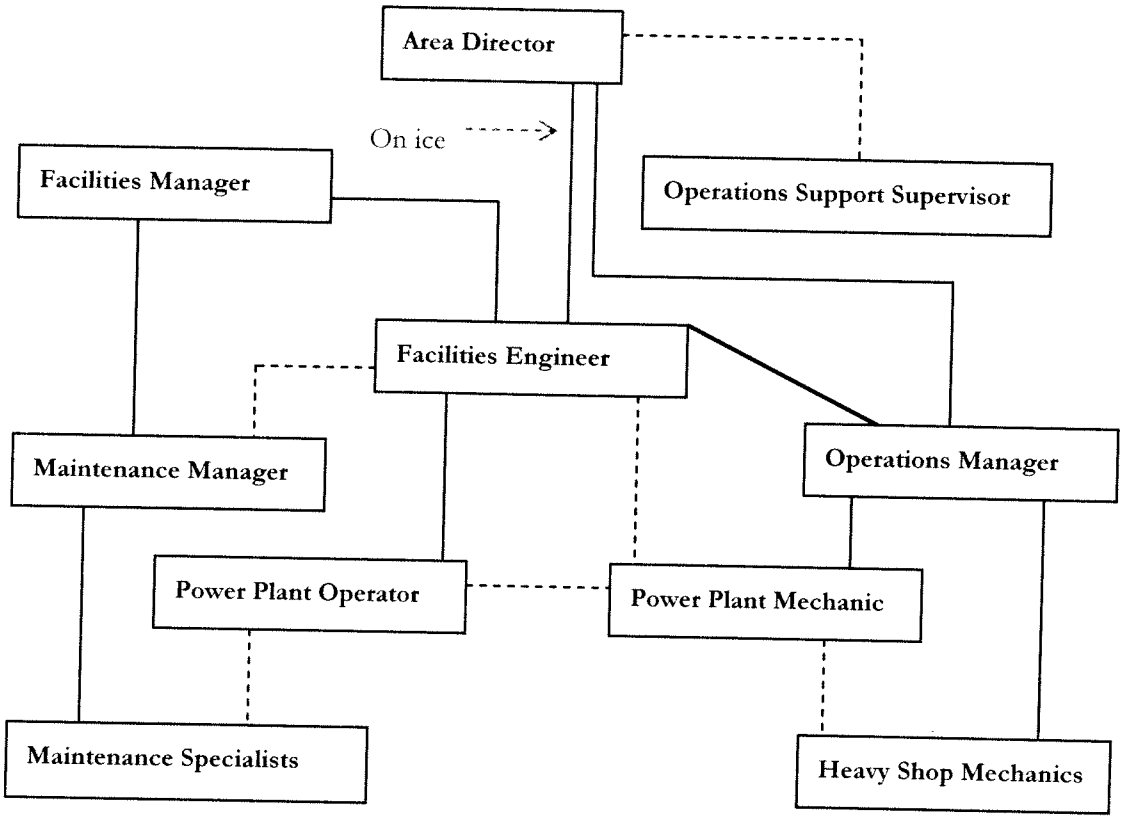
The Power Plant Mechanic/Operator and the Operations Manager are responsible for proper operation and maintenance of the power plant engines and generators. The Power Plant Mechanic/Operator will monitor all systems inside the power plant facility including the Direct Digital Control (DDC) systems.

The FEMC Maintenance Team is responsible for maintaining the building and the utilities supporting it, including fuel delivery systems, heating loops, and water circulation. FEMC Maintenance Specialists are available to assist in cases where FEMC responsibilities overlap Operations responsibilities (e.g. heat recovery and coolant circulation systems, etc.)

The Facilities Engineer provides direction regarding systems operations as needed and will provide oversight of all work on the power plant and associated systems.

Assistance from other departments may be required and requested by the Facilities Engineer.

Power Plant Organization Chart, South Pole Station



Discussion

Overview

The South Pole Power Plant consists of three 750-kW main generator sets powered by 3512B Caterpillar engines. A 250-kW "peaking generator" with a Caterpillar 3306B engine is also available. The three main generators are operated one at a time, allowing one to be on standby and one to be available for maintenance. The peaking generator will be used to pick up any excessive loads in support of the running main generator.

The online engine and the peaking engine are controlled by the Generator Control Module (GCM 30027) in the main control room.

In addition to the power generation equipment, the power plant houses heat recovery equipment used to heat the station buildings and the water system for South Pole. The heat recovery system and the heat rejection system consist of the following components: 1) an engine cooling loop where excess water-jacket heat is rejected through the radiators, 2) a water-jacket heat recovery loop where waste heat from the engine water jacket is added to the station heating loop, and 3) an exhaust stack heat recovery loop where waste heat from the exhaust stack is added to the station heat loop.

These loops are monitored and controlled by the DDC (Direct Digital Control) system.

AN8 fuel is used for all equipment operations at South Pole and is supplied to the power plant through the main circulation loop of the station. An emergency supply line is also available to allow fuel to be transferred from a portable tank.

Design specifications for the systems in the power plant are attached. (See appendix A: *Basis of Design Critical Criteria*)

Emergency power facilities include two 475-kW generators with Caterpillar 3412 engines in the old power plant.

Safety Considerations

The power plant presents a number of safety concerns. Among the most apparent are loud noise, high-voltage electricity, heavy lifting, slips, falls, high temperatures and potential for fire. Additionally, the CO2 fire suppression system in the engine room presents significant danger to the life and safety of anyone in that area. Due to the extreme hazards present, it is the responsibility of the Power Plant Mechanic to make sure anyone working in the power plant is aware of the hazards and the safety features present. Every precaution should be taken to ensure the power plant remains safe and accident-free, and any unsafe practices should be reported to the Operations Manager and the EH&S Coordinator immediately. Any person working on the Power Plant engines or support systems must be familiar with the Power Plant lockout and tag out procedures. Supervisors are responsible for ensuring personnel working for them are familiar with these procedures before working in the Power Plant.

Sign In/Sign Out Sheet

A sign in/sign out sheet will be posted on the door for the engine room in the power plant. Any person entering the area is required to sign in and out any time they are required to enter the area. Unauthorized personnel are not allowed in this area. In case of fire alarm all personnel are to exit the engine room area and log out of the power plant.

Power Plant Engine Room Safety Procedures

Safety warnings concerning the fire system in the power plant engine room are posted at the engine room entrance. This system suppresses fires by removing oxygen from the room and thus should be treated with respect. Only authorized personnel should enter this area. Before working in this area, each person will be instructed on the operation and warnings of the CO2 fire suppression system.

If the work to be performed will hinder any individual from exiting the area within 30 seconds in case of a fire, notify the Power Plant Mechanic and the Operations Manager. The fire system will be disabled during the work, and a fire watch will be posted in the power plant switchgear room during the entire time the fire system is disabled.

Note Any off-the-ground work will require the alarm system to be shut down and a watch posted. Off-ground work is defined as work 6 foot or more from the floor.

Startup Procedures

The engines/generators in the main power plant can be controlled from the main control room as well as from the control module beside each engine. To manually start an engine (or to bring a second engine on line), follow these steps:

1. Check the engine oil level and perform a visual inspection on the engine to be started.
2. In the engine control room, set the sequence switch on the Master Control Panel to position #1.
3. The engine will start up (and run parallel with the engine currently running).
4. Allow engine(s) to operate for a few minutes to make sure that no problems exist.
5. (If switching engines, turn the sequence control for the engine coming off line to any position other than Position #1. The engine will shut down automatically.)

6. Set the sequence control for the engines to the desired start-up sequence:

   Position #1=Generator Operating

   Position #2=Generator in Standby

   Position #3=Generator Down for Maintenance.

7. Monitor the engine just brought on line until the unit stabilizes and the Operator is satisfied no leaks or mechanical problems exist.

Special Circumstance: Black Start

Certain events may occur such that the New Power Plant will need to be started with out power, a condition commonly known as a "black start." This condition assumes that the plant has been down for an extended period of time and all power is dead including UPS back up systems.

One of the primary difficulties in this situation involves providing fuel to the engines. There is an in-line solenoid valve on the fuel supply to each engine. This valve is normally closed and will need to be powered open prior to starting one of the engines.

To accomplish this, one must utilize the Emergency Power Plant to back feed the New Power Plant. The New Power Plant has a breaker in the main engine control panel, which is used to back-feed the New Power Plant bus. Once emergency power is established, the breaker is closed and the plant becomes operational.

> **Note:** The emergency power breaker can only be closed when the engine breakers are open. At this point, a New Power Plant generator should be started. Once the generator has stabilized, the emergency power breaker is opened and the engine breakers are closed.

Engine/Generator Operating Procedures

The three main engines in the power plant are to be rotated on a schedule established by the Operations Manager and the Facilities Engineer. Initially, new engines should be rotated to establish a 3,000-hr differential between the engines. Once the differential has been established, the engines should be rotated regularly to maintain that differential. This allows major maintenance procedures to be staggered between years.

The Power Plant Mechanic is responsible for operating the engines and generators in accordance with manufacturer recommendations outlined in the Operations and Maintenance Manuals.

Maintenance Procedures

All persons entering the power plant engine room will be required to log in and out on a log sheet posted in the engine room entryway. The log sheet will record date and time of entry, purpose, and a description of work performed. Upon leaving the engine room workers will sign out.

All maintenance or repairs will be coordinated through the Facilities Engineer and detailed maintenance and repair records will be maintained in the MAPCON work order module. The Power Plant Mechanic will additionally maintain a work record log book recording work records for each engine.

Preventative maintenance on the engines and generators will occur in accordance with the manufacturer's operations and maintenance manuals. All maintenance intervals will be adhered to until sufficient evidence exists (through routine inspections or oil sampling) to establish that a deviation from the manufacturer's recommendation is warranted. The Facilities Engineer and the Operations Manager must approve any deviations.

If any maintenance is to be deferred because of parts unavailability or time constraints, the Facilities Engineer and the Operations Manager must be notified and the deferred maintenance approved in writing by the Facilities Engineer.

In addition to the log record of personnel entering the power plant engine room all work and all materials used in the power plant by any work center will be documented and recorded through MAPCON work orders.

Planned and Unplanned Power Outages

Planned Outages

Because of maintenance requirements to the main distribution system, planned outages will occur from time to time. The following procedures should apply:

1. Notify station management and personnel in accordance with RPSC Procedure OP-S-335: *Utilities Outage Reporting*.

2. Only those people directly involved should be in the power plant during the outage.
3. Communication procedures and work schedules should be coordinated prior to the outage by everyone involved.
4. Anyone not directly involved with the outage should make plans to remain in one building or outside during the time of the outage to avoid excessive heat loss from the buildings.
5. The Facilities Engineer submits an Incident Report (see below) to the Station Manager as soon as possible including the duration of the outage, repairs/maintenance performed during the outage, and any future repairs/preventive actions required.

Unplanned Outages

If an unplanned outage occurs, anyone affected by the outage should stay where they are to conserve heat and ensure safety.

1. The only people to respond to the power plant engine room should be the Power Plant Mechanic/Operator(s), the Facilities Engineer, the Operations Manager, and the on-call Electrician. In the event other assistance is needed, the Power Plant Mechanic will call for help.
2. During the austral summer, the Operations Manager will report to the switchgear room to keep the Communications Center (COMMS) informed of the situation and to assist with any questions or concerns.
3. Ensure that the Operations Manager and the Station Manager (the Area Director or Winter Site Manager) are kept apprised of the situation regularly.
4. The Facilities Engineer submits an Incident Report (see below) to the Station Manager as soon as possible including the duration of the outage, cause of the outage, repairs/ maintenance performed during the outage, and any future repairs/preventive actions required.

Incident reporting

For the purposes of this procedure, an "incident" is defined as any system or operator malfunction which caused or has the potential to cause the power plant or associated systems

to operate outside its design specifications or applicable procedures or to fail. These power plant systems include the following:

Engine generator systems

Power distribution systems

Heat recovery systems

Fire life safety systems

Potable water systems

Any incident meeting the above definition should be repaired immediately and documented in MAPCON using the work order system. Additionally any incidents should be reported in the following manner:

Include a brief description of the problem and the steps being taken to correct it in the weekly station SITREP.

Complete an incident report. See Attachment 2 (OP-S-321b): *Incident Reporting Template, South Pole Power Plant.* Send an electronic copy to the Facilities Engineer and keep a paper copy in the power plant files.

Heat Recovery Systems

The station heat recovery systems consist of two main heat recovery systems and a heat rejection system for the engines. These systems are controlled by the DDC system. The design parameters to be used as an indicator of proper operation are listed in the table below.

The Power Plant Mechanic/Operator will inspect the heat recovery systems every two hours when taking plant readings. The inspection should include checks for leaks or drips. Monitor inlet and outlet temperatures, glycol reserve tank levels, and expansion tank levels.

System Name	GPM Flow	Inlet Temp	Outlet Temp
Engine heat exchanger to station loop	220 GPM	198F	178F
Exhaust stack heat recovery	50 GPM	184F	230F

Note These temperature parameters are to be used as an indication of proper operation. Trends in either direction or major variances should be reported to the Operations Manager and the Facilities Engineer for consideration and correction.

Exhaust Cleaner Injection System

The main power plant engines are fitted with a soot catalyst injector system (see Appendix B) to periodically clean soot from the exhaust lines.

Operate the system as indicated below prior to each 500-hour service of the main engines.

This process should be performed on a fully warmed-up engine and exhaust system that is running at operating speed (1200 rpm).

- Close the ball valves located on the inlet air line, the outlet line to the exhaust heat exchanger, and the chemical holding tank
- Open the ¼" tee handle cock to relieve any pressure in the holding tank
- Unscrew the 3" iron cap on top of the chemical holding tank and add one 2-liter package of Drew Marine low temperature soot cleaner
- Replace iron cap and close the ¼" tee handle cock
- Open the ball valve in the outlet line to the exhaust heat exchanger
- Partially open the inlet air line ball valve
- Open the ball valve at the bottom of the chemical holding tank
- Open air line fully, operate for 2 minutes
- Close chemical tank ball valve, air valve and exhaust valve in that order
- Open ¼" tee handle cock slowly to relieve any pressure
- Remove the iron cap on the holding tank and ensure that the 2 liters of chemical cleaner have been injected into the system (Tank is empty of chemical).
- If not, repeat the process until all the chemical is used up
- Cool down engine
- Shut down engine

This process can be performed any time soot buildup is a concern in the heat exchanger, with a maximum interval of 500 hrs of engine operation.

Monitoring and Reporting

Inspections (watches) will take place at two-hour intervals or more frequently if deemed necessary by the Power Plant Mechanic. The inspections will include monitoring gauges and readings in the power plant as well as a visual inspection of all systems for leaks or malfunctions. See attachment 1 (OP-S-321a): *Main Power Plant Log, South Pole Station.*

The Power Plant Mechanic is responsible for the following reports:

1. Daily log records for power plant inspections (see Attachment 1)
2. Weekly SITREP information for the power plant and water distribution
3. Work records to be maintained in MAPCON on all work and maintenance done in the power plant (See RPSC Procedure OP-S-332: *Work Order Form Completion*)
4. Daily water quality records
5. Inventory records (in conjunction with Logistics personnel)
6. Power Outage Reports/Incident Reports (see above).

Maintaining Inventory

The Power Plant Mechanic is responsible for maintenance of the inventory for the power plant engines and generators. Maintenance of inventory not directly associated with the engines and generators will be directed to each responsible work center by the Facilities Engineer. All work centers should record all usage of parts for work orders and order replacement parts as required.

Handling Waste Material

The Power Plant Mechanic will work with the Waste Specialist(s) and the EH&S Coordinator to ensure that liquids and other waste materials are properly packaged and separated. The handling of waste materials in the power plant is to be done in accordance with RPSC Waste Management Procedures (OP-MSP-8xx series). All waste will be stored in well marked containers as WASTE and will not be stored in the power plant. Waste materials will be removed from the power plant immediately after they have been containerized.

Spills

Spills must be reported and contained in accordance with USAP Spill Response procedures (see OP-M-255: *Hazardous Materials/Spill Response* for details.)

Emergency Fueling of Power Plant

An emergency fueling line for the power plant allows fuel to be supplied to the day tanks via an outside connection. One of several portable fuel tanks can be connected to the connection on the south end of the power plant arch. The fuel can be transferred either with the aid of a transfer pump or by gravity feed if the tank is positioned above the arch. See RPSC Procedure OP-S-302: *Fuel Storage, Transfer, Testing, and Filling.*

References

Power Plant Basis of Design (See Appendix A for critical criteria)

Caterpillar Operations and Maintenance Manual for 3512B Engine and Generator Set

RPSC Procedure OP-S-335: Utilities Outage Reporting

RPSC Procedure OP-S-332: Work Order Form Completion

RPSC Waste Management Procedures: OP-MSP-8xx series

RPSC Procedure OP-M-255: Hazardous Materials/Spill Response

RPSC Procedure OP-S-302: *Fuel Storage, Transfer, Testing, and Filling*

Records

Record Identification, Format, & Owner	Active Location	Facility Storage	Retention Time	Ultimate Disposition
Sign In/Sign Out Sheets: paper sheets filed in power plant office; Facilities Engineer	Power Plant office, available from Facilities Engineer	N/A	Active: One Year	Recycle
Daily Log Sheets, paper sheets filed by Power Plant Mechanic	Power Plant Control Room files, available from Power Plant Mechanic	Maintained by Operations Manager in Denver	Active: One Year. Storage: Length of Contract	Recycle
MAPCON Work Order Records: paper records and electronic files, Power Plant Mechanic	Paper: Power Plant Control Room Electronic: MAPCON Database, backed up by IT	Electronic backups maintained by IT	Active: on-site for two years Storage: (DHQ) length of contract	Recycle
Power outage report: paper copy; Facilities Engineer	Power Plant office, available from Facilities Engineer	N/A	Active on site 5 years	Recycle
Incident report: paper copy; Facilities Engineer	Power Plant office, available from Facilities Engineer	N/A	Active on Site, 2 years	Recycle

Appendices, Attachments

Appendix A: ***Basis of Design Critical Criteria***

Appendix B: ***Exhaust Soot Cleaner Diagram***

Attachment 1 (OP-S-321a): ***Main Power Plant Log, South Pole Station***

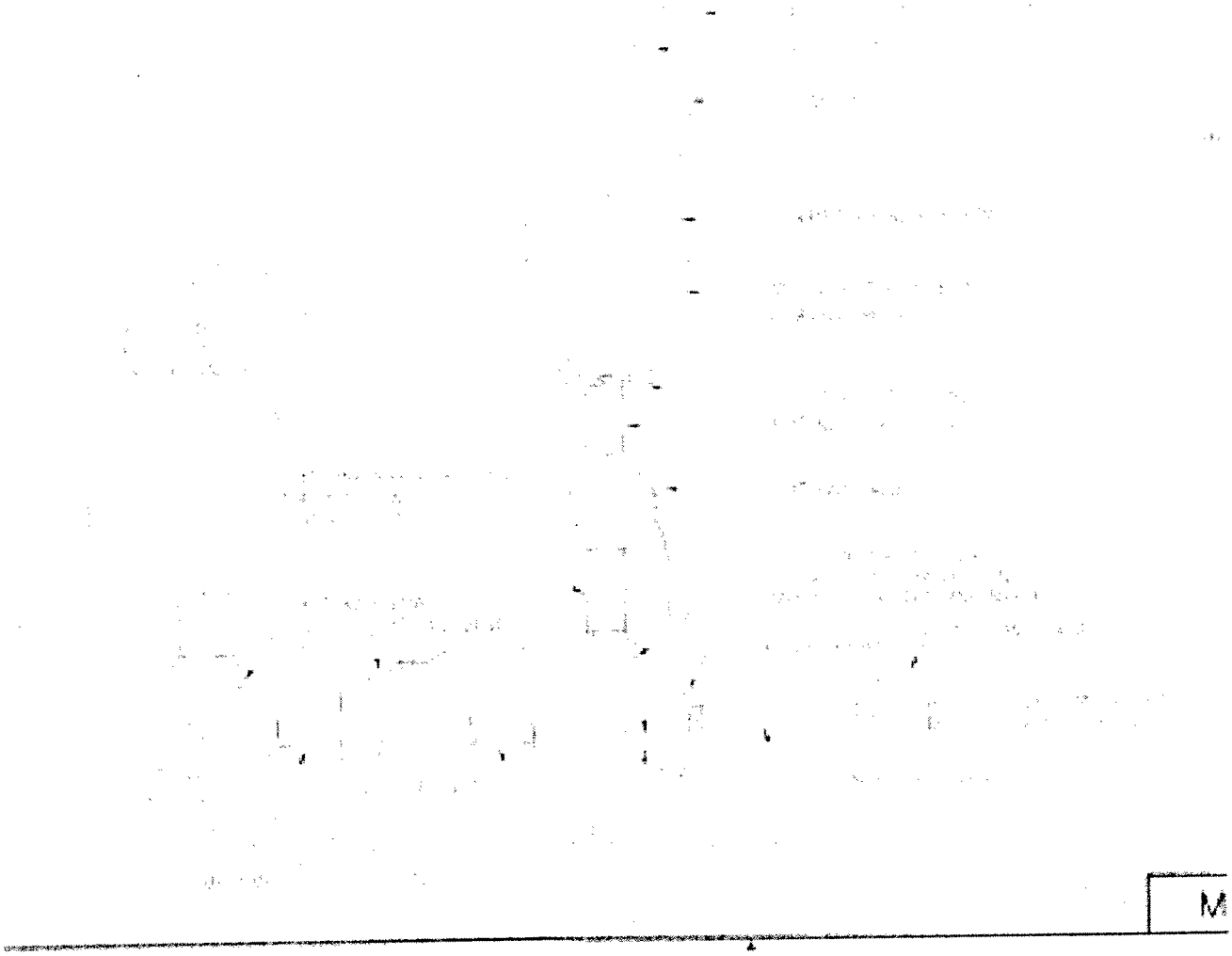
Attachment 2 (OP-S-321b): ***Incident Reporting Template, South Pole Power Plant***

Appendix A: Basis of Design Critical Criteria

Key Basis Of Design Considerations for SPSM New Power Plant	
3.0 Architectural	
1.4 arch interior diameter	55'
1.4.1 Floor to underside	15'
2.3 Thermal insulation	
Walls	R-70
Roof/Ceiling	R-70
Floors/soffit	R-70
2.5.3 Floor area Tabulations	
Power Generation/POL	3,855 sq/ft
Contorl	460 sq/ft
Water Treatment	515 sq/ft
Sub-Station	470 sq/ft
Fuel Rm	275 sq/ft
Remote Radiator	300 sq/ft
Hallway	400 sq/ft
Accessory Rm #1	170 sq/ft
Accessory Rm #2	115 sq/ft
Restroom	70 sq/ft
Vestibule	70 sq/ft
Arch (Net unheated area)	4,815 sq/ft
4.0 Structural	
2.0 Roof loads	
No Storage allowed on Roof	0
Live Load for maintenance	25 PSF
floor live load	125 PSF
6.0 Bulkhead walls	
Maximum depth of snow above the arch	20'
5.0 Mechanical	
2.1 Engine Generator system	
2.1.1 Peak Load (Design load,continous rating)	750KW
Caterpillar 3512 engine/generator set	
Caterpillar 3406C peaking	330KW
Note (Provisions for peaking to be replaced with larger unit are in BOD)	
Engine parameters (Caterpillar)	
Oil Temp	190-210F
Oil Pressure	55-70 PSI
Fuel Pressure	55-65 PSI
engine coolant temp Max allowable	210F
Crankcase vent filter inlet	0-.03"H2O
2.3.1.1 Remote Radiator Plenum Temp.	7 F
2.3.3 Jacket Water Flow	220 GPM
Jacket Water temp into Skid	~198 F
Jacket Water Temp out of Heat Exchanger	~178F
Maximum heat yeild	1900 MBH
2.4 Exhaust Stack Gas	
2.4.2 Fluid Transfer Flow	50 GPM
Transfer Fluid inlet temp (To Heat Exchanger)	~184 F
Transfer Fluid Outlet temp (MAX)	~230 F
Min Exhaust Gas Temp	350F
Max Exhaust Gas Temp	~1050F
2.6 Coolant, Transfer Fluid (Dowthemm 4000) 60/40)	

Coolant Engine (GM Spec 6038 (Caterpillar ELC)	
2.6.1 Min coolant design temp	-100 F
3.0 Ventilation Systems	
Cooling Air Flow Rate	14,111 SCFM
AHU1 Fan Size	7,056SCFM
AHU2 Fan Size	7,056 SCFM
3.3 Exhaust Make Up Air	
3.3.1 Restroom	175 ACM
3.3.2 Fuel Room	360 ACM
3.3.3 Power Generation Room	10,160 ACM
3.3.4 Control Room (AHU3)	790 ACM
3.3.5 Substation (AHU4)	1,975 ACM
3.3.6 Power Generation Room Make up (AHU5)	505ACM
3.3.7 Substation Heating Fan	1,028 ACM
3.4 Remote radiator	
Duct Air Velocity	775FPM
Exhaust Air Duct	1,000 FPM
5.0 Water Treatment	
5.2.3 Flow rate circulating back to well	~13GPM
5.2.3 Flow rate to Station water system	~4 GPM
5.2.12 Storage Capacity (Two 3000 gal tanks)	6000 gallon
Fuel System	
7.2.2 Day Tanks capacity (2 tanks 1000gal ea)	2000 gal
6.0 Electrical System	
3.5 Generator output charachteristics	
Waveform deviation total	5%
Total harmonic distortion	5%
Maximum short circuit amps	7800/ amp/generator
Droop	0-10%
Votage Regulation	+/- 1%
Voltage regulation on 3% speed change	2%
response time to load	1 cycle

Appendix B: Soot Cleaner Diagram



Raytheon
Polar Services

South Pole Power Plant Incident Report

Date:

Incident Description:

(Brief description of problem and cause if known. If incident involved a power outage, see procedure OP-S-321 for additional required information.)

Recommendations for Corrective Action:

Immediate steps to be taken:

Future steps: